Elements of Cosmology, Astronomy and Astrophysics – Perspectives from Kinetic Theory and Thermodynamics

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25th November 2025

Abstract: In any proposed thermodynamic mathematical relation two fundamental conditions must be satisfied: (a) the units on each side must be the same and (b) the thermodynamic character on each side must also be the same. If either of these conditions is not satisfied then the proposed equation or inequality is invalid. Temperature is always an intensive thermodynamic coordinate; mass is always an extensive thermodynamic coordinate. The thermodynamic mathematical relations of the kinetic theory of an ideal gas satisfy these two conditions. Despite invoking the laws of thermodynamics and the kinetic theory of gases, cosmology, astronomy and astrophysics violate the laws of thermodynamics by making temperature non-intensive and mass non-extensive, and also violate the kinetic theory of an ideal gas by applying gravitational and Coulomb forces between the particles of an ideal gas when, by definition, there are no forces between the particles of an ideal gas except when they collide elastically with one another and the walls of their container. Consequently, the gaseous theory of the stars is certainly false, and, inter alia, so too the theory of black hole thermodynamics.

1. Thermodynamic coordinates; thermodynamic balance

Pure numbers and physical constants such as G, the universal constant of gravitation, and $\mathscr{R}$, the universal gas constant, have no thermodynamic character since they can never be thermodynamic variables. Consider a homogeneous brick at thermal equilibrium. Divide the brick into two equal parts. Those quantities which are halved are called extensive thermodynamic coordinates and those quantities which don't change are called intensive thermodynamic coordinates [1]. For instance, the mass is halved and so is the volume; mass and volume are extensive thermodynamic coordinates. Temperature does not change; neither does density and pressure. Temperature, density and pressure are intensive thermodynamic coordinates. The quotient of two different extensive coordinates produces an intensive coordinate. Density is a simple example: density is mass divided by volume: $D = M/V$.

There are quantities that can arise in thermodynamic expressions that are neither intensive nor extensive but still have a thermodynamic character. Take the brick example. The division into halves does not halve the surface area and the surface area does not stay the same. In fact, the total surface area of the two half bricks is greater than the surface area of the initial brick. The thermodynamic character of surface area is system dependent.

Mathematically speaking an extensive thermodynamic coordinate is a homogeneous function of degree 1. An intensive thermodynamic coordinate is a homogeneous function of degree 0. Determining the thermodynamic character of a collection of terms is easily done by adding and subtracting the degrees of the thermodynamic

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coordinates in an expression. For example, mass M is homogeneous degree 1; so $1/M$ is degree -1. Volume V is homogeneous degree 1; so $1/V$ is degree -1. Now density is $D = M/V$ so density has degree 1 + (-1) = 1 − 1 = 0. Density is intensive. Now consider the ideal gas law $PV = n\mathcal{R}T$. Pressure is homogeneous degree 0, V is degree 1, n is the number of moles and is therefore extensive so degree 1, $\mathcal{R}$ being a physical constant is irrelevant and T is homogeneous degree 0. So the left side is degree 0 + 1 = 1 and the right side is degree 1 + 0 = 1. Hence the left and right sides are both extensive so the ideal gas equation is thermodynamically balanced. It is also unit balanced.

All thermodynamic equations or inequalities must have the same units on each side and must have the same thermodynamic character on each side [2-5]. If one side, for example, has the units of mass, say kilogrammes, and the other side has units of time, say seconds, the expression is certainly wrong. Similarly, in a thermodynamic relation if the left side is intensive but the right side is not intensive, then it is certainly wrong, even if the units balance. If a thermodynamic expression does not have unit balance and also thermodynamic balance then it is definitely wrong.

2. The kinetic theory of ideal gas

The setting for the kinetic theory of an ideal is a container. The volume of a gas is determined by the volume of its container. A gas has no shape and takes on the shape of its container. Experiments on gases in containers resulted in the theory of an ideal gas and the ideal gas equation $PV = n\mathcal{R}T$ or equivalently, $PV = NkT$ where N is the number of gas particles and k is Boltzmann's constant.

The particles of an ideal gas have no charge. There are no forces between the particles of an ideal gas except when they collide elastically with one another and the walls of their container. The elastic collisions are very brief impulsive forces by which the particles lose no kinetic energy. Without the container the volume, pressure and temperature of the gas are indeterminate. Since there are no other forces between the ideal gas particles there are no gravitational forces between them. In addition, since the particles are not charged there are no Coulomb (i.e., electrical) forces between the particles either. Nevertheless, the cosmologists, astronomers and astrophysicists completely dispense with the container and combine the ideal gas law with gravitational and Coulomb forces between the ideal gas particles and in so doing violate the ideal gas law. The equations they derive from this also produce violations of the laws of thermodynamics by making temperature non-intensive and mass non-extensive. The 0^{th} and 2^{nd} laws of thermodynamics require temperature to be intensive. Consequently, non-intensive temperature violates both the 0^{th} and 2^{nd} laws of thermodynamics.

Gases do not and cannot compress themselves. Compression of a gas always requires the action of an external agent applying a force in the presence of real walls. The action of a bicycle pump is a simple and commonly known means of gas compression. Yet the cosmologists, astronomers and astrophysicists always claim that gases can compress themselves, and in the absence of any containment to boot. They call this 'gravitational collapse', due, they assert, to gravitational forces between the particles of the gas, which they treat as ideal or 'perfect', contrary to the kinetic theory of an ideal gas that they employ. They argue, without any scientific evidence whatsoever, that a gas will compress itself if it is sufficiently massive, despite violation of the kinetic theory of gases. Science by irrational imagination is not science, only a perversion of science, a form of mysticism or magic pretending to be science. Following such 'science' is taking a trip down a garden path.

3. The 0th and 2nd laws of thermodynamics

Thermodynamics speaks generally of systems. A system is always finite, by definition [6]. The surroundings of a system consist of other systems. Cosmologists, astronomers and astrophysicists frequently invoke infinite thermodynamic systems; in doing so they violate the laws of thermodynamics and the ideal gas yet again. It is impossible to define the volume, pressure and temperature of an 'infinite system' in order to apply the kinetic theory of an ideal gas and the laws of thermodynamics. 'Infinite system' is a contradiction in terms.

The 0th law of thermodynamics is a very simple statement of an experimental fact. If a body A is in thermal equilibrium with another body B and also with another body C, then bodies B and C are in thermal equilibrium with one another. One can see from the 0th law that if bodies B and C are now brought into contact then there is no change in their temperature. The total mass and total volume of the combine bodies B and C is the sum of their masses and their volumes respectively. Mass and volume are additive whereas temperature is not: the temperature of the combined bodies B and C is the same as the temperature of B and C separately, so temperature is not additive. Hence, another way of characterising an extensive thermodynamic coordinate is that it is additive; e.g., the mass of a body is the sum of the masses of its parts and the volume of a body is the sum of the volumes of its parts. Similarly, an intensive thermodynamic coordinate is not the sum of parts; e.g., the temperature of a body is not the sum of the temperatures of its parts. When two bodies of different temperatures are brought into contact the equilibrium temperature of the resultant body is not the sum of the temperatures of the two initial bodies.

The 2nd law of thermodynamics relates entropy to temperature. The entropy of a system is the sum of the entropies of its parts. Thus, entropy is extensive, so it is homogeneous degree 1.

3. Examples of thermodynamic violations

(i) **Black hole entropy.** According to the cosmologists, astronomers and astrophysicists the entropy S of their black hole is proportional to the surface area A of the hole, where the surface is imaginary, being the area of the 'event horizon' of the black hole. The Bekenstein-Hawking black hole entropy equation is [7-10]:

$$S = \frac{\pi c^3 k}{2hG} A$$

Here h is Planck's constant, c is the speed of light, G is the universal constant of gravitation and k is Boltzmann's constant. The area A is that of a sphere. The surface area of a sphere is not extensive. The left side of this equation is extensive. All terms on the right side except spherical surface area A are either pure numbers of physical constants, so they are thermodynamically irrelevant. Hence, this equation is thermodynamically unbalanced, being extensive on the left side but not extensive on the right side. It is therefore false. This is reaffirmed by noting that the radius of the event horizon is the so called 'Schwarzschild radius' r_s given by:

$$r_s = \frac{2GM}{c^2}$$

where M is the mass of the black hole. Now the surface area of a sphere is $A = 4\pi r^2$. Using this and r_s the Bekenstein-Hawking black hole entropy is:

$$S = \frac{8\pi^2 kG}{hc} M^2$$

Entropy, being extensive, is homogeneous degree 1. Mass, being extensive, is homogeneous degree 1 so that $M^2 = M \times M$ is homogeneous degree (1 + 1) = 2. Thus the equation is homogeneous degree 1 on the left side but homogeneous degree 2 on the right side. It is therefore false.

(ii) **Black hole temperature.** Hawking's black hole temperature equation, which is etched into his tombstone in the floor of Westminster Abbey, is [11, 12]:

$$T = \frac{hc^3}{16\pi^2 kGM}$$

The left side is intensive, homogeneous degree 0, but the right side is homogeneous degree -1 due to the black hole mass in the denominator. Thus, this equation is also false.

(iii) **Black hole entropy in terms of black hole temperature.** Solving the Hawking black hole temperature equation for M and substituting this into the black hole entropy equation gives:

$$S = \frac{hc^5}{32\pi^2 kGT^2}$$

The left side is extensive (homogeneous degree 1) whereas the right side is intensive (homogeneous degree 0) due to temperature in the denominator. Note that an intensive thermodynamic coordinate raised to any power is still intensive: homogeneous degree $0^n = 0$ for all real values n. Thus, this equation is also false. Black hole thermodynamics is nonsensical.

(iv) **Stellar Temperatures.** The astronomers and astrophysicists claim that the stars are hot balls of gaseous plasma. Their theory uses the kinetic theory if an ideal gas which they combine with gravity. Since there are in fact no gravitational forces between the particles of an ideal gas their theory violates the kinetic theory of an ideal gas at the very outset. This in turn leads to violations of the laws of thermodynamics. For instance, according to Chandrasekhar, "*the mean temperature*"[13] of an ideal gas star is given by this equation:

$$\bar{T} = \frac{\beta}{2k}\frac{GM\mu H}{R}$$

where β is a constant, M is the mass of the star, μ is the molecular weight of the gas particles, H is the mass of the proton and R the spherical radius. So the mass of a gas particle is μH. Now the radius of a sphere in this context is neither intensive nor extensive; it is homogeneous degree ⅓ []. So the left side is intensive (homogeneous degree 0) but the right side is homogeneous degree (1 − ⅓) = ⅔. Therefore the equation is false. Furthermore, a temperature is assigned to gravitational potential energy because $GM\mu H / R$ is gravitational potential energy. But potential energy does not have a temperature. So, again, the equation is false.

(v) **Galactic temperatures.** According to the astronomers and astrophysicists galaxies are formed from clouds of uncontained gas that compress themselves. They advance what they call the "*virial temperature*"[14], given by this equation:

$$T_{vir} \cong \frac{0.13}{k}\frac{GM\mu m_p}{r_h}$$

where M is the mass of the gas cloud, μ is the molecular weight of the gas particles, m_p is the mass of the proton and r_h is the median radius of the cloud. This equation has the very same character as the mean stellar temperature in example (iv): the left side is intensive (homogeneous degree 0) but the right side is homogeneous degree (1− ⅓) = ⅔, and a temperature is assigned to gravitational potential energy because $GM\mu m_p / R$ is gravitational potential energy, which does not have a temperature. Therefore the equation is false.

(vi) **Gravitational collapse of a gas.** Just how massive must a gas (somehow) become to magically compress itself? The astronomers and astrophysicists have an equation for that too, of course. They have equations for all their violations of kinetic theory and thermodynamics. In this case the crucial mass they call 'the Jeans mass', given by this equation [15]:

$$M_J = \left(\frac{3}{4\pi\rho_o}\right)^{1/2}\left(\frac{5kT}{G\mu m_H}\right)^{3/2}$$

where ρ_o is the constant initial density of the alleged uncontained spherical ideal gas cloud and m_H is mass of the hydrogen atom. Mass is extensive, so homogeneous degree 1. The density and the temperature on the right side of the equation are both intensive (homogeneous degree 0). Since degree 0 raised to any power is still 0, the right side of this equation is intensive. The equation is not thermodynamically balanced so it is nonsense despite being unit balanced.

(vii) **Controlled nuclear fusion.** There is currently under construction in France a gigantic tokomak with which it is claimed controlled nuclear fusion will be achieved: the ITER project. The theory upon which this project is based is nuclear fusion in gaseous stars. Seven countries are contributing money to the project which will cost tens of billions just to construct the hardware. Staffing and operational expenses are enormous. Yet it is doomed to fail. The theory of nuclear reactions in gaseous stars is completely false due to violations of the kinetic theory of gases and the laws of thermodynamics [16]. For example, approximate temperatures at which stellar nuclear reactions are alleged to occur is given by this equation [17]:

$$T \approx \xi \frac{\mu_m c^2 Z_1^2 Z_2^2}{k}$$

where ξ is a numerical coefficient, c the speed of light, Z_1 and Z_2 the number of protons in nuclei 1 and 2 respectively. The left side of this expression is intensive but the right side is composed entirely of pure numbers and physical constants and therefore has no thermodynamic character whatsoever. Consequently the expression is false.

4. The lesson learned

The cosmologists, astronomers and astrophysicists do not understand and have never understood the ideal gas law and the basic laws of thermodynamics. Consequently they are oblivious to their violations of these laws, constructing theories that have no foundation in science. Their theories of gaseous stars and galaxy formation are false.

The stars are not hot balls of gaseous plasma; they are condensed matter [18, 19].

The ITER project will never achieve controlled nuclear fusion; its huge tokomak nothing but scrap metal.

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